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(54) Method and cleaning assembly for cleaning an ink jet print head in a self-cleaning ink jet printer system

(57) A cleaning assembly (170) for removing contaminants from the surface (90) of an ink jet print head (60) in a self-cleaning ink jet printer (10). The print head (60) defines a plurality of ink channels (31) terminating in orifices (25) with a surface (90) surrounding the orifices (25). A gutter (17) is disposed opposite the print head surface (90) for collecting ink droplets (100) ejected from the orifices (25). A cleaning assembly (170) includes a cup (190) defining a cavity (197) with an open end (195) adapted to make contact with the print head surface (90). An inflow channel (210) provides the entry pathway for cleaning liquid to flow into the cavity (197) via a gap (220). An outflow channel provides an exit pathway for the flow of cleaning liquid from cavity (197). The inflow channel (210) and outflow channel are arranged to direct the flow of cleaning liquid into the cavity (197), over the print head surface (90) and orifices (25) so that contaminants are removed from the print head surface (90) and orifices (25).

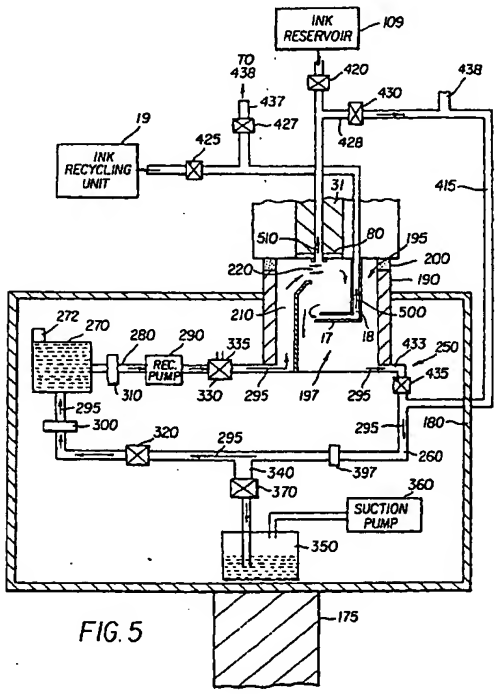

FIG. 5

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Description

[0001] This present invention relates to methods and system for cleaning ink jet print heads utilized in an ink jet printer system. More particularly, the present invention relates to a method and system for hydrodynamically cleaning ink jet print heads.

[0002] Modern color printing relies heavily on ink jet printing techniques. The term "ink jet" as utilized herein is intended to include all drop-on-demand or continuous ink jet propulsion systems including, but not limited to, thermal ink jet, piezoelectric, and continuous, which are well known in the printing arts. An ink jet printer produces images on a receiver by ejecting ink droplets onto the receiver medium, typically paper, in an image-wise fashion. The advantages of non-impact, low-noise, low energy use, and low cost operation in addition to the capability of the printer to print on plain paper are largely responsible for the wide acceptance of ink jet printers in the marketplace.

[0003] In this regard, "continuous" ink jet printers utilize electrostatic charging tunnels that are placed close to the point where ink droplets are ejected in the form of a stream. The electrostatic charging tunnels electrically charge selected ink droplets. The charged ink droplets are then deflected downstream by the presence of deflector plates that have a predetermined electric potential difference between them. A gutter can be utilized to intercept the charged ink droplets, while uncharged ink droplets are free to strike the receiver medium. Ink drops not utilized for printing are transferred to the gutter where they can be recycled. Continuous inkjet systems thus create a continuous stream of ink drops, generated by periodically perturbing an associated print head orifice with, for example, a piezoelectric transducer.

[0004] In the case of "on demand" ink jet printers, a pressurization actuator is utilized to produce the ink jet droplet at every orifice. One of two types of actuators, either a heat actuator or piezoelectric actuator, may be utilized to produce the ink jet droplet. In the case of a heat actuator, a heater is placed at a convenient location to heat the ink. A quantity of ink will then phase change into a gaseous steam bubble, thereby raising the internal ink pressure sufficiently to permit an ink droplet to be expelled onto the receiver medium. In the case of piezoelectric actuators, a piezoelectric material possessing piezoelectric properties is utilized to produce an electric field when a mechanical stress is applied. The converse is also true. An applied electric field produces a mechanical stress in the material. Naturally occurring materials possessing such characteristics include quartz and tourmaline. The most commonly produced piezoelectric ceramics include lead zirconate titanate, barium titanate, lead titanate, and lead metaniobate.

[0005] Recently, a new type of continuous ink jet printer was disclosed. US Patent No. 6,079,821 which issued to Chwalek et al., on June 6, 2000, describes a continuous ink jet printer in which on demand asymmetric heating of an ink jet causes selected drops to deflect. In one mode of operation, selected drops are deflected toward an image-receiving medium while the other drops are intercepted in a canopy-type gutter placed in close proximity (e.g., 3 mm) to the ink jet orifice plate.

[0006] Inks for high-speed ink jet printers, whether of the "continuous" or "piezoelectric" type, have a number of special characteristics. For example, the ink should include a nondrying characteristic; so that drying of ink in the ink ejection chamber is hindered or slowed to such a state that by the occasional spitting of ink droplets, the cavities and corresponding orifices are kept open. The addition of glycol facilitates free flow of ink through the ink jet chamber.

[0007] Of course, the ink jet print head is exposed to the environment where printing occurs. Thus, the aforementioned orifices are exposed to many kinds of air born particulates. Particulate debris may accumulate on surfaces formed around the orifices and in the orifices and chambers themselves. The ink may combine with such particulate debris to form an interference that blocks the orifice or alters surface wetting, thereby inhibiting the proper formation of the ink droplet. The particulate debris should be cleaned from the surface and orifice to restore proper droplet formation. In the prior art, cleaning is commonly accomplished by brushing, wiping, spraying, vacuum suction, and/or spitting of ink through the orifice.

[0008] Thus, inks used in ink jet printers can be said to have the following problems: the inks tend to dry-out in and around the orifices resulting in clogging of the orifices; and the wiping of the orifice plate causes wear on the plate and wiper, the wiper itself producing particles that clog the orifice.

[0009] Ink jet print head cleaners are known. An ink jet print head cleaner is disclosed in U.S. Patent 4,970,535 titled "Ink Jet Print Head Face Cleaner" issued November 13, 1990, in the name of James C. Oswald (the '535 Patent). The '535 Patent discloses an ink jet print head face cleaner that provides a controlled air passageway through an enclosure formed against the print head face. Air is directed through an inlet into a cavity in the enclosure. The air that enters the cavity is directed past ink jet apertures on the head face and exits via an outlet. A vacuum source is attached to the outlet to create a sub-atmospheric pressure in the cavity. A collection chamber and removable drawer are positioned below the outlet to facilitate disposal of removed ink. The technique uses heated air to remove the ink. Heated air is less effective for cleaning than a liquid solvent and can also damage fragile electronic circuitry that may be present on the print head face.

[0010] Other print head cleaning systems attempt to include physical elements to clean debris from ink jet print heads. For example, a skip stroke wiping system is disclosed in U.S. Patent 5,774,140 titled "Skip Stroke Wiping System for Ink Jet Print Heads," issued June 30, 1998, in the name of Kris M. English (the '140 Patent).

The '140 Patent discloses a skip stroke wiping method for cleaning an ink jet print head and involves wiping and scraping steps. While the apparatus and method described in the '140 Patent will remove debris, the harsh scraping and wiping steps can wear down the print head over time, thereby requiring a complicated wiping mechanism that is costly to replace if damaged.

[0011] US Patent Application Serial Number 09/206,272 to Sharma et al. describes a cleaning assembly involving a removable gutter (not fixed) and a cup that sealingly engages the print head. Cleaning liquid supplied to the cup flows between a septum and the print head surface, thereby creating a zone of high shear. The cleaning liquid then exits via an outlet provided on the opposite side of the septum. This cup and septum arrangement cannot be utilized to clean the printer when the gutter is fixed.

[0012] Based on the foregoing, it can be appreciated that what is needed to efficiently clean an ink jet print head is a non-invasive print head cleaning method and system, one that involves the flow of fluids to remove debris and contaminants present on an ink jet print head, without damaging the print head itself. Such a method and system, if implemented, would avoid the aforementioned problems associated with present print head cleaning methods and systems, particularly those that involve heating techniques or complicated wiping mechanisms.

[0013] It is an object of the present invention to provide an ink jet printer having a cleaning assembly for cleaning a surface of an ink jet print head.

[0014] It is another object of the present invention to provide an ink jet printer having a cleaning assembly for cleaning a surface of an ink jet print head having a fixed type gutter.

[0015] It is another object of the present invention to provide a method and system for pumping a cleaning liquid across the print head surface to achieve cleaning of the surface and print head orifices.

[0016] It is yet another object of the present invention to remove used cleaning fluid from the print head, thereby cleaning contaminants from the surface of the print head and any associated print head parts, such as an orifice or orifice plate.

[0017] It is still another object of the present invention to provide a method and system for dislodging and removing contaminants from an ink jet print head and associated print head parts, including the gutter, utilizing a cleaning liquid that is pumped across the print head and simultaneously removed.

[0018] With the above objects in view, a cleaning assembly for use in an ink jet printer is disclosed. The ink jet printer includes a print head having a print head surface and one or more ink orifices disposed on the surface. The printer also includes a structural member that functions as a gutter for collecting ink, such that the gutter is disposed opposite the print head surface. The cleaning assembly is configured to clean contaminant from the print head surface.

[0019] According to an exemplary embodiment of the present invention, a self-cleaning printer system comprises a print head defining a plurality of ink channels disposed therein, wherein each ink channel terminates at an orifice. The print head also includes a surface thereon surrounding all the orifices. The print head is capable of jetting ink through the orifices. Ink jets are heated, causing ink drops to form and selectively deviate for printing. A receiver medium or a gutter can intercept the ink drops. In one method of operation, ink is selectively deflected onto a receiver medium (e.g., paper or transparency) supported by a platen disposed adjacent the print head, while the non-deflected ink drops are intercepted by a gutter.

[0020] Ink intercepted by the gutter can be recycled. Contaminants, such as oily film-like deposits or particulate matter, may reside on the print head surface thereby completely or partially obstructing the orifice. The oily film may, for example, be composed of grease. The particulate matter, on the other hand, may be composed of particles of dirt, dust, metal and/or encrustation of dried ink. The presence of contaminants interferes with the proper ejection of ink droplets from their respective orifices and therefore may give rise to undesirable image artifacts, such as banding. It is thus desirable to clean contaminants from the print head surface and orifices.

[0021] Therefore, a cleaning assembly is disposed relative to the surface and/or orifices for directing a flow of cleaning liquid along the surface and/or across the orifices, thereby cleaning contaminants therefrom. As described in detail herein, the cleaning assembly has an inflow channel appropriately angled to direct cleaning liquid at the orifices.

[0022] In another embodiment, cleaning liquid may be forced into the orifices and then out through an outlet provided in the print head. This back-flow enhances cleaning. In yet another embodiment, cleaning liquid may be supplied to the print head surface through a channel provided in the gutter. Thereafter, cleaning liquid can be directed to flow out of a cup via an outlet pipe, a channel in the gutter or through the orifices. In still another embodiment, ink jetting out of the orifices may be collected in a cup and swept away by cleaning liquid flowing into the cup. A pump for supplying cleaning liquid through the cup, print head or gutter is provided and provides suction. In addition, a filter can be used to filter particulate matter from the liquid for later disposal. In yet another embodiment, an ultrasonic transducer is used to enhance cleaning by energizing the cleaning liquid. In still another embodiment, cleaning liquid may carry gas bubbles to aid in cleaning of contaminant. The cleaning liquid may also be surged forward and backward by a piston device, thereby increasing cleaning efficiency.

[0023] An advantage of the present invention stems from the facts that fluids are non-invasively pumped across the print head in a manner that does not damage

the print head.

[0024] Another advantage of the present invention lies in the ability of the channel to deliver fluids to the print head without damaging the print head surface.

[0025] A further advantage of the present invention stems from the fact that contaminants and debris can be removed from the print head and associated print head parts without the use of expensive and cumbersome heating techniques typical of many present prior art print head cleaning systems.

[0026] These and other objects, features and advantages of the present invention will become apparent to those skilled in the art upon a reading of the following detailed description when read in association with the drawings depicted herein.

[0027] While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter of the present invention, it is believed the invention will be better understood from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a view in elevation of a self-cleaning ink jet printer with a page-width print head;

FIG. 2(a) is a fragmentation view in vertical section of a print head where four ink streams from left hand side are non-deflected (intercepted by gutter), while fifth, sixth, seventh and eighth ink streams are deflected out of the plane of the paper and intercepted by receiver medium;

FIG. 2 (b) is a side view of print head with a fixed gutter attached showing the pathway for deflected and non-deflected ink drops;

FIG. 2 (c) is a side view of print head with a fixed gutter attached, the gutter having a slot for allowing cleaning liquid to flow past;

FIG. 3 is a fragmentation view in vertical section of the print head showing some of the orifices encrusted with contaminant;

FIG. 4 is a view in elevation of a cleaning assembly for removing the contaminant;

FIG. 5 is a view in vertical section of the cleaning assembly with a cup and channel disposed to direct cleaning liquid to the print head orifices, surface of orifice plate and fixed gutter;

FIG. 6 is a view in vertical section of the cleaning assembly with a cup and channel disposed to direct cleaning liquid to the print head orifices, surface of orifice plate and fixed gutter with a slot;

FIG. 7 is an enlarged fragmentation view in vertical section of the cleaning assembly showing the contaminant being removed from the surface of the orifice plate and fixed gutter by flowing cleaning liquid;

FIG. 8 is a view in vertical section of the cleaning assembly including a cup with channel disposed to direct cleaning liquid and gas bubbles to the print head orifices, surface of orifice plate and to gutter;

FIG. 9 is a view in vertical section of the cleaning assembly, the cleaning assembly including a cup with channel and pressure pulse generator disposed to direct cleaning liquid to the print head orifices, surface of orifice plate and to fixed gutter;

FIG. 10 is a view in vertical section of the cleaning assembly including a cup with channel and ultrasonic generator disposed to direct cleaning liquid and pressure waves to the print head orifices, surface of orifice plate and to gutter;

Fig. 11 is a view in vertical section of the cleaning assembly including a cup with adjustable channel disposed to direct cleaning liquid to the print head orifices, surface of orifice plate and to fixed gutter; and

Fig. 12 is a view in cross-section of a cup with adjustable channel to enable horizontal section of channel to fit beneath fixed gutter and to fully overlap orifices.

[0028] References in the detailed description refer to like references in the figures unless otherwise indicated.

[0029] The present description is directed to elements forming part of, or cooperating more directly with, an apparatus and method in accordance with the present invention. It is to be understood that elements not specifically shown or described herein may take various forms well known to those skilled in the art. Therefore, referring to **FIG. 1**, there is depicted a self-cleaning printer, generally referred to as **10**, for printing an image **20** on receiver medium **30**. Receiver medium **30** may be configured as a reflective-type receiver (e.g., paper) or a transmissive-type receiver (e.g., transparency). Receiver medium **30** is supported on a platen roller **40**, which is capable of being rotated by a platen roller motor **50** engaging platen roller **40**. Thus, when platen roller motor **50** rotates platen roller **40**, receiver medium **30** advances in a direction illustrated by a first arrow **55**.

[0030] Referring to **FIGS. 1, 2(a), 2(b)**, and **2(c)**, printer **10** also comprises a print head **60** disposed adjacent platen roller **40**. Print head **60** includes a plurality of ink channels **70**, a surface **90** and a plurality of print head orifices **25**, and heaters **79** surrounding each orifice **25**. For simplicity, the terms "orifice" and "orifices," "heater" and "heaters," and "channel and "channels" shall be used interchangeably throughout with identical reference numerals assigned to the plural and singular form of the element. As shown most clearly in **FIGS. 2(b) and 2(c)**, a fixed gutter **17** is provided for capturing ink drops that are not deflected into the receiver medium **30** and surface **90** faces receiver medium **30**. In order to print image **20** on receiver medium **30**, an ink droplet can be released from orifice **25** in the direction of receiver medium **30** so that receiver medium **30** can intercept the ink droplet. In **FIG. 2(a)**, counting from left to right, the first four orifice heaters **79** have not been energized which causes drops **21** to be intercepted by gutter **17**. The next four heaters **79** are energized, causing drops **23** to deflect and land on receiver medium **30**. Ink drops

24 on receiver medium 30 form the image 20. Ink drops 23 are deflected out of the plane of the drawing and therefore do not appear to be deflected in FIG. 2(a). Deflected ink drops 23 are more clearly illustrated in FIGS. 2(b) and 2(c).

[0031] Referring again to FIGS. 1, 2(a), 2(b), 2(c) and FIG. 4, therein is illustrated a self- cleaning printer system which includes an image source 600 (shown in FIG. 1) such as a scanner or a computer that provides raster image data, outline image data in the form of a page description language, or other forms of digital image data. The image source 600 is converted to half-toned bitmap image data by an image processing unit 610, which stores the image data in memory. A plurality of heater control circuits 620 read data from memory within the image processing unit 610 and apply time-varying electrical pulses to a set of orifice heaters 79 that are part of a print head 60. These electrical pulses are applied at an appropriate time, and at an appropriate orifice 25, thereby permitting deflected ink drops 23 from a continuous ink jet stream to form spots on a receiver medium 30, typically paper. The spots are formed on receiver medium 30 in an appropriate position predetermined by data residing in the memory of image processing unit 610. Non-deflected ink drops 21 formed at the non-printing area are intercepted by gutter 17.

[0032] Still referring to FIGS.1 and 4, receiver medium 30 is moved relative to page-width print head 60 by rotation of platen roller 40, which is electronically controlled by paper transport control system 120. Paper transport control system 120 is in turn controlled by controller 130. Paper transport control system 120 disclosed herein is, by way of example only, a single configuration and many different configurations are possible based on the teachings herein. In the case of page width print heads, it is most convenient to move receiver medium 30 past a stationary print head. However, in the case of a scanning print system, it is usually more convenient to move the print head along one axis (i.e., the subscanning direction) and the receiver medium 30 along an orthogonal axis (i.e., the main scanning direction) in a relative raster motion. Controller 130, which is connected to platen roller motor 50, ink pressure regulator 110 and a cleaning assembly, according to the invention described herein, enables printing and print head cleaning operations. Structure and operation of the cleaning assembly is described in detail hereinbelow. In one embodiment, the controller 130 may be a model CompuMotor controller available from Parker Hannifin in Rohrnert Park, California.

[0033] Referring again to FIGS. 1, 2, 4, and FIG. 5, ink is contained in an ink reservoir 109 under pressure. In non-printing state, continuous ink jet drop streams are unable to reach receiver medium 30 due to the position of ink gutter 17. In such a position, ink gutter 17 blocks the stream, thereby permitting a portion of the ink to be recycled by ink recycling unit 19. Gutter 17 is a fixed gutter and forms part of print head 60. Ink recycling unit 19 reconditions the ink and feeds it back to ink reservoir 109. Such ink recycling units are well known in the art. The ink pressure suitable for optimal operation will depend on a number of factors, including the geometry and thermal properties of the orifices 25 and thermal properties of the ink. A constant ink pressure can be achieved by applying pressure to ink reservoir 109 under the control of ink pressure regulator 110.

[0034] The ink is distributed to the back surface of print head 60 by an ink channel device 35 and through ink channel 31, as depicted in FIG. 3. The ink flows preferably through slots or holes etched through a silicon substrate of print head 60 to a front surface 90, wherein a plurality of orifices 25 and heaters 79 are disposed. By fabricating print head 60 from silicon, it is possible to integrate heater control circuits 620 with the print head 60. Non-deflected ink drops 21 are intercepted by gutter 17, while deflected ink drops 23 land on receiver medium 30. Deflection may be caused by a variety of methods including the asymmetric heating method discussed in U.S. Patent Application No. 08/954317 to Chwalek, et al.

[0035] Referring now to FIG. 3, it has been observed that surface 90 and channels 70 may become fouled by contaminant 140. Contaminant 140 may be, for example, an oily film or particulate matter residing on surface 90. Contaminant 140 also may partially or completely obstruct one or more of orifices 25. The particulate matter may be, for example, particles of dirt, dust, metal and/or encrustations of dried ink. The oily film may be, for example, grease or the like.

[0036] The presence of contaminant 140 is undesirable because when contaminant 140 completely obstructs an orifice 25, ink droplets 100 are prevented from being ejected from an effected orifice 25. Also, when contaminant 140 partially obstructs an orifice 25, the flight of ink droplets 100 may be diverted from first axis 107 to travel instead along a second axis 117. If ink droplets 100 travel along second axis 117 or third axis 118, ink droplet 100 will land on receiver medium 30 in an unintended location. In this manner, such complete or partial obstruction of orifice 25 leads to printing artifacts, such as "banding", a highly undesirable result. The presence of contaminant 140 may also alter surface wetting and inhibit the proper formation of ink droplets 100. It is thus desirable to clean (i.e., remove) contaminant 140 to avoid printing artifacts.

[0037] Therefore, referring to FIGS. 1, 4, 5, 6 and 7, a cleaning assembly, generally referred to as 170, is disposed proximate to surface 90 for directing the flow of cleaning liquid along surface 90 and across orifices 25 to clean contaminant 140 therefrom. Cleaning assembly 170 is movable from a first or "rest" position 172a spaced-apart from surface 90 to a second position or "cleaning position" 172b engaging surface 90. This movement can be accomplished, for example, via an elevator 175 coupled to controller 130. Cleaning assembly 170 may comprise a housing 180 for reasons de-

scribed presently. Disposed in housing **180** is a generally rectangular cup **190** having an open end **195.** Cup **190** defines a cavity **197** communicating with open end **195.** An elastomeric seal **200** is attached to open end **195** by, for example, a suitable adhesive. The elastomeric seal **200,** which may be composed of rubber or the like, is sized to encircle gutter **17** and one or more orifices **25** thereby sealingly engaging surface **90.**

[0038] Referring to **FIGS. 2(b), 2(c), 5, 6, 7, 8, 9,** and **10,** cleaning liquid is pumped into cavity **197** through inflow channel **210.** Inflow channel **210** directs fluid to orifices **25** and surface **90.** Cleaning liquid leaves cavity **197** by one of a number of outflow channels. For example, one possible outflow channel is the gutter channel **18** wherein suction is applied to the gutter channel **18** causing cleaning liquid to leave cavity **197** following arrow **500.** Alternatively, by applying suction to outflow channel **428** provided in print head **60,** cleaning liquid may exit cavity **197** following arrow **510.** Cleaning liquid may also leave cavity **197** through outflow pipe **433** in cup **190.** As described in more detail hereinbelow, a preferred pathway for outflow of cleaning liquid from cavity **197** may be employed to optimize cleaning of contaminant **140** from surface **90** and/or orifices **25.** This method may also be utilized to flush contaminant **145** from gutter **17** and gutter channel **18.**

[0039] By way of example only, and not by way of limitation, the velocity of the liquid flowing through gap **220** may be about 1 to 20 meters per second. Also by way of example only, and not by way of limitation, the height of gap **220** may be approximately 0.05 to 3 mm.

[0040] Referring again to **FIGS. 5, 6, 7, 8, 9,** and **10,** interconnecting cup **190** and cleaning liquid reservoir **270** form a closed-loop piping circuit **250.** It will be appreciated that piping circuit **250** is in fluid communication with gap **220** for recycling liquid through gap **220.** In this regard, piping circuit **250** comprises a first piping segment **260** extending from cavity **197** to a reservoir **270** containing a supply of cleaning liquid. Piping circuit **250** further comprises a second piping segment **280** extending from reservoir **270** to inflow channel **210.** Disposed in second piping segment **280** is a recirculation pump **290.** Pump **290** pumps cleaning liquid from reservoir **270,** through second piping segment **280,** into cavity **197,** through first piping segment **260** and back to reservoir **270,** as illustrated by a plurality of second arrows **295.** It will be appreciated that for this flow path, valves **330, 435, 320** are open while valves **425, 427, 420, 430** and **370** are shut. A first filter **300** may be disposed in first piping segment **260,** while a second filter **310** may be disposed in second piping segment **280.** Second filter **310** filters (i.e., separates) contaminant **140** from the cleaning liquid as it circulates through piping circuit **250.** It will be appreciated that portions of piping circuit **250** adjacent to cup **190** are preferably made of flexible tubing in order to facilitate the uninhibited translation of cup **190** toward and away from print head **60.** Translation is accomplished via elevator **175.** It is preferable to remove contaminant **140** from the cleaning liquid as it is re-circulated through piping circuit **250.** This is preferred so that contaminant **140** is not redeposited onto surface **90** and across orifices **25.** Thus, first filter **300** and second filter **310** operate to filter contaminant **140** from the cleaning liquid re-circulating through piping circuit **250.**

[0041] In the event that there is a desire to squirt ink simultaneously out of one or more of the orifices **25** while cleaning liquid is being pumped into gap **220,** fifth valve **420** can be opened. Furthermore, if cleaning liquid needs to be disposed rather than be recycled, first valve **320** remains closed while third valve **370** opened, thereby permitting cleaning liquid to be collected in sump **350.** At the end of the cleaning cycle, it is preferable to drain cavity **197** before it is detached from surface **90** thereby limiting spillage.

[0042] Drainage of cavity **197** may be accomplished in the following manner. Valves **330, 425, 427, 420, 430** and **320** remain closed while valves **435** and **370** are opened and three-way valve **330** is switched to air vent **335.** Thereafter, suction pump **360** is activated, thereby drawing cleaning liquid from cavity **197.** Suction pump **360** drains cup **190** and associated piping of cleaning liquid before cup **190** is detached and returned to first position **172a.** Liquid flowing into sump **350** may be recycled into reservoir **270** when desired.

[0043] Referring to **FIGS. 5** and **6,** cleaning liquid is permitted to flow out of cavity **197** through gutter **17** following arrow **500.** In order to direct fluid from cleaning liquid reservoir **270** to gap **220** and cavity **197,** and thereafter exit gap **220** and cavity **197** through gutter channel **18,** valves **330, 427,** and **320** are opened while valves **425, 420, 430, 435,** and **370** are closed. Cleaning liquid exiting seventh valve **427** and travels in fifth piping segment **437** and joins fourth piping segment **415** at location **438.** Cleaning liquid may be collected in sump **350** for further use or as waste by closing valve **320** and opening valve **370.** When cleaning liquid is directed to flow through gutter channel **18** following arrow **500,** contaminant **145** in gutter channel is removed. When desirable, the flow of liquid out of gap **220** and cavity **197** may be directed through a combination of pathways. For example, an additional pathway for cleaning liquid to leave gap **220** and cavity **197** may be employed by opening valve **435,** thereby causing liquid to flow out through outflow pipe **433.**

[0044] Referring still to **FIGS. 5** and **6,** cleaning liquid may be directed to gap **220** and cavity **197** from cleaning liquid reservoir **270** and directed to leave gap **220** and cavity **197** through one or more orifices **25.** This is accomplished by pumping cleaning liquid while valves **330, 430,** and **320** are open and valves **425, 427, 420, 435** and **370** are shut or closed. When cleaning liquid is directed to flow through orifices **25** following arrow **510,** contaminant **140** present in ink channel **31** leading to orifices **25** is cleaned. Thus, cleaning liquid forced into print head **60** through orifices **25** leaves the ink channel **31** through outflow channel **433.**

[0045] Referring to **FIGS. 2(b), 2(c)** and **6** of the present invention, gutter **17** can be designed with a slot **560** cut into first wall **570** and second wall **572** of gutter **17.** Cleaning liquid arriving at gap **220** can continue to flow through slot **560** following arrow **515** of **FIG. 6,** thereby relieving stress on the frame of gutter **17** caused by the high rate of flow of cleaning liquid arriving through inflow channel **210.**

[0046] Returning to **FIG. 1,** elevator **175** may be connected to cleaning cup **190** for elevating cup **190** so that seal **200** sealingly engages surface **90** when print head **60** is at second position **172b.** To accomplish this result, elevator **175** is connected to controller **130.** Controller **130** controls the operation of elevator **175.** Of course, when the cleaning operation is completed, elevator **175** may be lowered so that seal **200** no longer engages surface **90.**

[0047] As best seen in **FIG. 1,** in order to clean the page-width print head **60** via cleaning assembly **170,** platen roller **40** can be moved to provide space for cup **190** to engage print head **60.** An electronic signal from controller **130** activates a motorized mechanism (not shown) that moves platen roller **40** in the direction of first double-ended arrow **388,** thereby providing space for the upward movement of cup **190.** Controller **130** also controls elevator **175** for transporting cup **190** from first position **172a** (i.e., not engaging print head **60**) to second position **172b** (i.e., shown in phantom) engaging print head **60.** When cup **190** engages print head cover plate **80,** cleaning assembly **170** circulates liquid through cleaning cup **190** and over print head surface **90.** When print head **60** is required for printing, cup **190** is retracted into housing **180** by elevator **175** to its resting first position **172a.** Cup **190** may be advanced outwardly from and retracted inwardly into housing **180** in the direction of second double-ended arrow **388.**

[0048] Referring to **FIGS. 5, 6, 7, 8, 9** and **10,** the cleaning liquid emerging from cup **190** and piping segment **415** is initially contaminated with contaminant **140** and contaminant **145.** It is desirable to collect this cleaning liquid in sump **350** rather than recirculate the liquid. Therefore, this contaminated liquid is directed to sump **350** by closing first valve **320** and opening third valve **370,** while suction pump **360** operates. The liquid will eventually be free of contaminant **140** and contaminant **145** and may be circulated by closing third valve **370** and opening first valve **320.** A detector **397** disposed in first piping segment **260** determines when the liquid is clean enough to be recirculated.

[0049] Information from detector **397** can be processed and used to activate the valves thereby directing the exiting of cleaning liquid to sump **350** or into recirculation. In this regard, detector **397** may be configured as a spectrophotometric detector. In any event, at the end of the cleaning procedure, suction pump **360** is activated and third valve **370** is opened so as to suction into sump **350,** any trapped liquid remaining between second valve **330** and first valve **320** (valve **330** is open to air vent **335).** This process prevents the spillage of liquid when cleaning assembly **170** is detached from surface **90.** This process also causes surface **90** to become substantially dry, thereby permitting print head **60** to function without impedance from cleaning liquid drops disposed about orifices **25.**

[0050] To resume printing, eighth valve **430** is then closed and fifth valve **420** is opened to prime ink channels **70** with ink. Seventh valve **427** is also opened to recycle ink from gutter **17.** Suction pump **360** is again activated, and third valve **370** is opened to suction away liquid remaining in cup **190.** Alternatively, cup **190** may be detached and a separate spittoon (not shown) may be brought into alignment with print head **60** to collect drops of ink ejected from ink channels **70** and orifices **25** during the priming of print head **60.**

[0051] Those skilled in the art will appreciate that the mechanical arrangement described above is but one example of an ink jet print head cleaning method and system. Many different configurations are possible. For example, print head **60** may be rotated outwardly about a horizontal axis **389** to a convenient position to provide clearance for cup **190** to engage print head orifice plate **80.** According to the method and system described herein, print head **60** is configured to include a gutter **17.**

[0052] Referring to **FIG. 8,** there is shown a second embodiment of the present invention. In this second embodiment of the invention, a pressurized gas supply **390** is in communication with gap **220** thereby permitting a pressurized gas (e.g., pressurized nitrogen or pressurized argon) to be injected into gap **220.** The gas forms a multiplicity of gas bubbles **395** in the liquid to enhance the cleaning of contaminant **140** from surface **90** and/or orifices **25.** Gas bubbles **395** also enhance the cleaning of contaminant **145** in gutter **17.**

[0053] A third embodiment of the present invention is illustrated in **FIG. 9.** In this third embodiment, a pressure pulse generator, such as a piston arrangement, generally referred to as **400,** is in fluid communication with gap **220.** Piston arrangement **400** comprises a reciprocating piston **410** for generating a plurality of pressure pulse waves propagated by the cleaning liquid as it travels through gap **220.** Piston **410** reciprocates between a first position and a second position, thereby causing the cleaning liquid to surge forward and backward through gap **220,** orifices **25** and gutter channel **18.** The second position is shown in phantom in **FIG. 9.** Such "to-and-from" motion helps dislodge contaminant **140** and contaminant **145.** The pressure wave effectively enhances the cleaning of contaminant **140** from surface **90** and/or orifice **25** and the cleaning of contaminant **145** in the gutter.

[0054] The piston arrangement depicted at **400** of **FIG. 9** represents one possible technique for generating a pressure pulse. Another technique is illustrated in **FIG. 10,** wherein a pressure pulse is produced in gap **220.** In **FIG. 10,** an ultrasonic generator **245** is depicted. Ultrasonic generator **245** is capable of generating a plurality

of pressure waves **247** that enhance the cleaning of contaminant **140** from surface **90** and /or orifice **25.** The cleaning of contaminant **145** from gutter **17** is also thereby enhanced. By way of example only, and not by way of limitation, pressure waves **247** may have a frequency of 17 kHz and above.

[0055] A fourth embodiment of the present invention is illustrated in **FIGS.11** and **12.** In this fourth embodiment, a horizontal section **630** is predisposed about channel **210** as shown to extend over orifices **25** so that a narrow passage between horizontal section **630** and the orifice plate **80** is defined. This arrangement provides for more efficient cleaning since a zone of high shear is provided over the orifices **25.** It will be appreciated that the extremity of horizontal section **630** with respect to the channel **210** should not interfere with gutter **17** during docking of cup **190** with orifice plate **80.** Therefore, as shown in **FIG. 12** a channel wall **215** is provided and extends within cavity **197** along a surface of cup **190** to form the inflow channel **210.** The position of channel wall **215** is made adjustable to avoid collision with gutter **17** during docking. Once the cup **190** is engaged to surface **90** on orifice plate **80,** the position screw assembly **640** is used to adjust location of horizontal section **630.** Another mechanism (not shown) for adjusting the position of horizontal section **630** is to translate the cup along the surface **90** after the horizontal section **630** has cleared gutter **17** during docking. It will be appreciated that fourth embodiment of the present invention may be combined with ultrasonic generator **245,** pressurized gas supply **390,** and piston arrangement **400.**

[0056] The cleaning liquid mentioned hereinabove may be composed of any suitable liquid solvent composition, such as water, isopropanol, diethylene glycol, diethylene glycol monobutyl ether, octane, acids and bases, surfactant solutions and any combination thereof. Complex liquid compositions may also be utilized in accordance with the present invention, such as microemulsions, micellar surfactant solutions, vesicles and solid particles dispersed in the cleaning liquid.

[0057] Based on the foregoing, it can be appreciated that an advantage of the present invention stems from the fact that cleaning assembly **170** is capable of cleaning contaminant **140** from surface **90** and/or orifice **25** without resorting to brushes or wipers. Such brushes or wipers might otherwise damage surface **90** and/or orifices **25,** because inflow channel **210** directs the cleaning liquid at a high velocity to surface **90** and/or orifices **25.** Additionally, cleaning assembly **170** cleans contaminant **140** from surface **90** of orifice plate **80** and/or orifices **25** and contaminant **145** from gutter **17** while the gutter is fixed to print head **60.**

[0058] Another advantage of the present invention lies in the fact that the cleaning efficiency is increased. Gas bubbles **395,** pressure pulse generator **400,** and ultrasonic generator **245** all work to enhance cleaning.

[0059] Those skilled in the art can appreciate that the present invention can be modified without departing from the essential teachings of the invention. For example, a heater may be utilized to heat liquids pumped across surface **90,** into orifices **25** and into gutter channel **18** of **FIGS. 5, 6, 7, 8, 9,** and **10,** thereby enhancing cleaning of the surface of print head **90,** and/or orifice **25** and gutter channel **18.** This is particularly useful when the cleaning liquid is of a type that increases in cleaning effectiveness as the temperature of the cleaning liquid is increased. In another example, a multiple color printer having a plurality of print heads respectively corresponding to a plurality of colors, one or more dedicated cleaning assemblies per color can be utilized to avoid cross-contamination of print heads by inks of different colors.

[0060] In yet another example wherein modifications may be made to the present invention without departing from the essential teachings of the invention, a contamination sensor may be utilized to detect when cleaning is necessary. Such a contamination sensor may be configured as a pressure transducer in fluid communication with ink disposed in channels flowing to print head **60,** thereby detecting the rise in ink back pressure when partially or completely blocked channels attempt to eject ink droplets. Such a contamination sensor may also be configured as a flow detector in communication with ink in such channels, thereby detecting low ink flow when partially or completely blocked channels attempt to eject ink droplets.

[0061] The contamination sensor may also be configured as an optical detector in optical communication with the surface of print head **60** and orifices **25,** thereby optically detecting the presence of contaminants by reflection or emissivity. The contamination sensor may also be implemented as a device that measures the amount of ink released into a spittoon-like container during predetermined periodic purging of associated ink channels. In this case, the amount of ink released into the spittoon-like container is measured by the device and compared against a known amount of ink that should be present in the spittoon-like container if no orifices were blocked by contaminants. Similar modifications may also be made to the configuration depicted in **FIGS. 1, 4, 5, 6, 8, 9** and **10.**

[0062] While the invention has been described with particular reference to its preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements of the preferred embodiments without departing from the invention. In addition, many modifications may be made to adapt a particular situation and material to a teaching of the present invention without departing from the essential teachings of the invention.

Claims

1. In a self-cleaning printer (10) having a print head (60) with a print head surface (90) and a plurality of

ink channels (70) terminating in orifices surrounded by said print head surface, said print head further including a fixed gutter (17) for receiving non-deflected ink drops exiting said orifices, a cleaning assembly (170) for removing contaminants from said print head surface and said orifices **characterized by:**

a cup (190) defining a cavity (197) with an open end adapted to make contact with said print head surface;
an inflow channel (210) providing an entry pathway into said cavity; and
an outflow channel (18, 250, 510, 560) providing an exit pathway from said cavity;

wherein said inflow and outflow channels are predisposed for directing the flow of cleaning liquid into said cavity, over said print head surface and said orifices and out of said cavity of said cup so that contaminants are removed from said print head.

2. The cleaning assembly of claim 1 wherein said outflow channel comprises at least one of a gutter channel (18) within said fixed gutter, a channel (510) within said print head, slots (560) within said fixed gutter, and an outflow pipe (250) predisposed about said cup.

3. The cleaning assembly of claim 1 further comprising:

an elevator (175) engaged to said cup and configured to move said cup from a rest position to a cleaning position; and
a controller (130) for directing the movement of said elevator.

4. The cleaning assembly of claim 1 further comprising:

a cleaning liquid reservoir (270) for storing cleaning liquid; and
a piping circuit (250) forming a closed-loop between said cleaning liquid reservoir and said cup.

5. The cleaning assembly of claim 4 further comprising a recirculation pump (290) for pumping cleaning liquid from said cleaning reservoir to said cup through said piping circuit.

6. The cleaning assembly of claim 1 wherein said inflow channel includes a gap (220) which directs fluid flow in a substantially horizontal direction over said print head surface.

7. The cleaning assembly of claim 6 further comprising a pressurized gas supply (390) in fluid communication with said inflow channel and adapted to introduce pressurized gas within said cavity of said cup via said gap.

8. The cleaning assembly of claim 6 further comprising a pressure pulse generator (400, 410) in fluid communication with said inflow channel and adapted to introduce a plurality of pressurized pulse waves that are propagated in said inflow channel as cleaning liquid travels through said gap.

9. The cleaning assembly of claim 1 further comprising a channel wall (215) predisposed within said cavity and extending substantially along an inner surface of said cup.

10. The cleaning assembly of claim 9 wherein said channel wall further comprises a horizontal section (630) predisposed about said inflow channel to extend over said orifices.

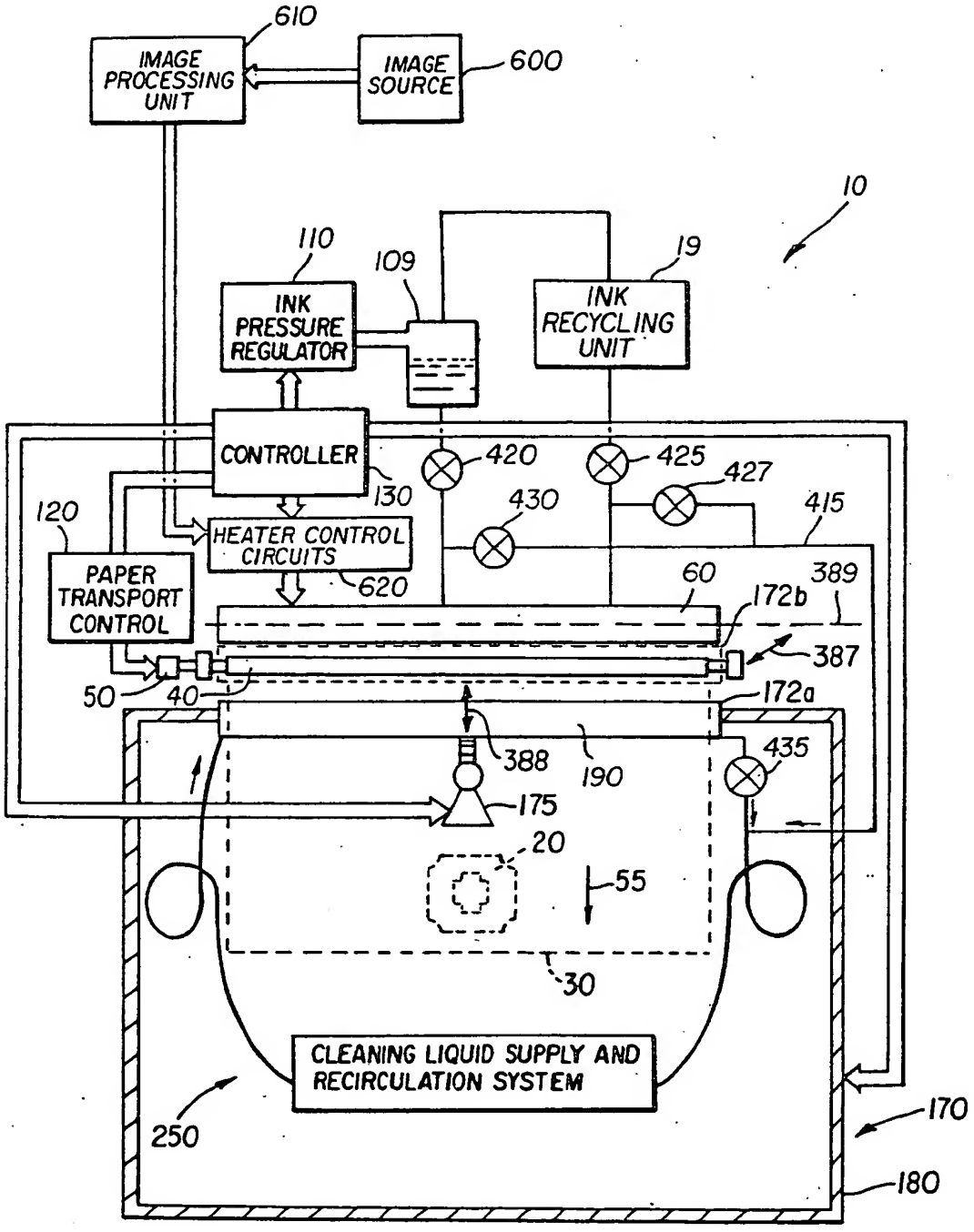
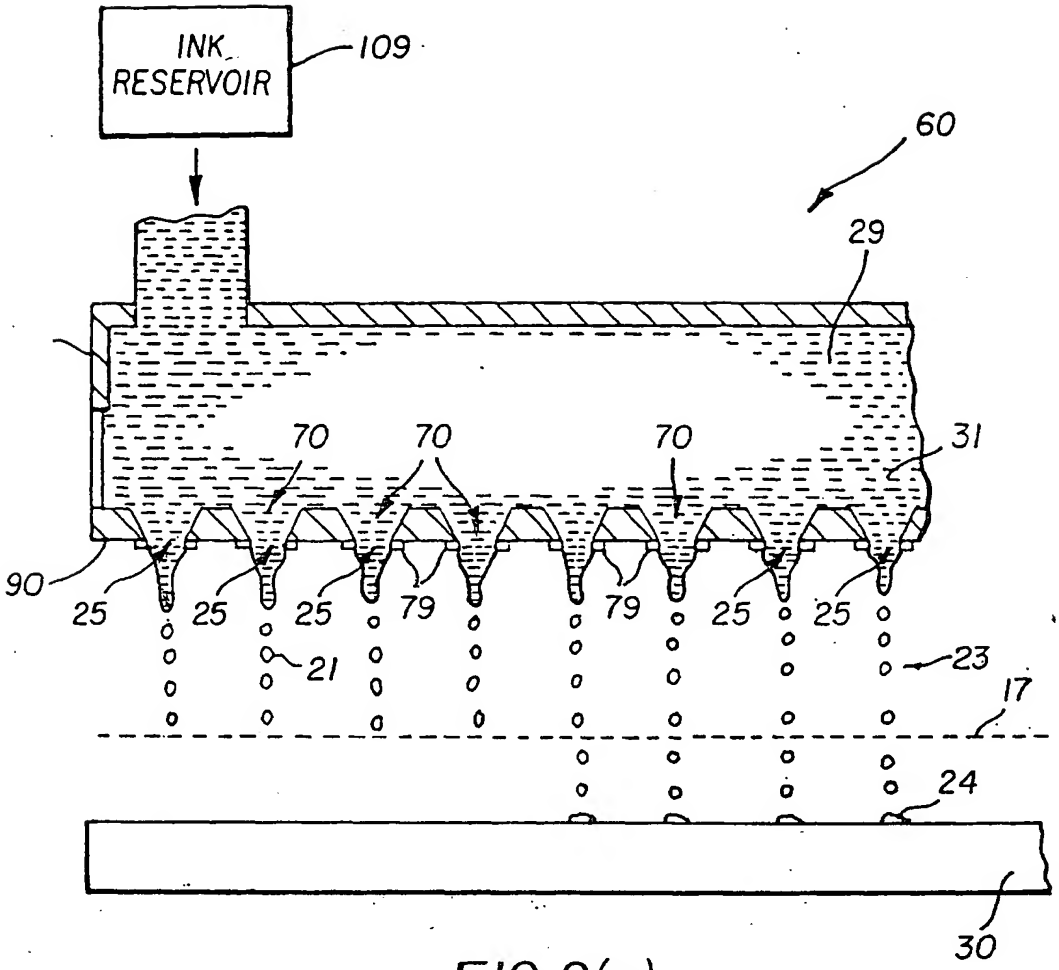

610
IMAGE PROCESSING UNIT
IMAGE SOURCE
600
10
110
109
19
INK PRESSURE REGULATOR
INK RECYCLING UNIT
CONTROLLER
130
420
425
427
430
415
120
HEATER CONTROL CIRCUITS
620
PAPER TRANSPORT CONTROL
60
389
172b
387
50
40
172a
388
190
435
175
20
55
30
CLEANING LIQUID SUPPLY AND RECIRCULATION SYSTEM
250
170
180

FIG. 1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60
29
31
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90
25
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25
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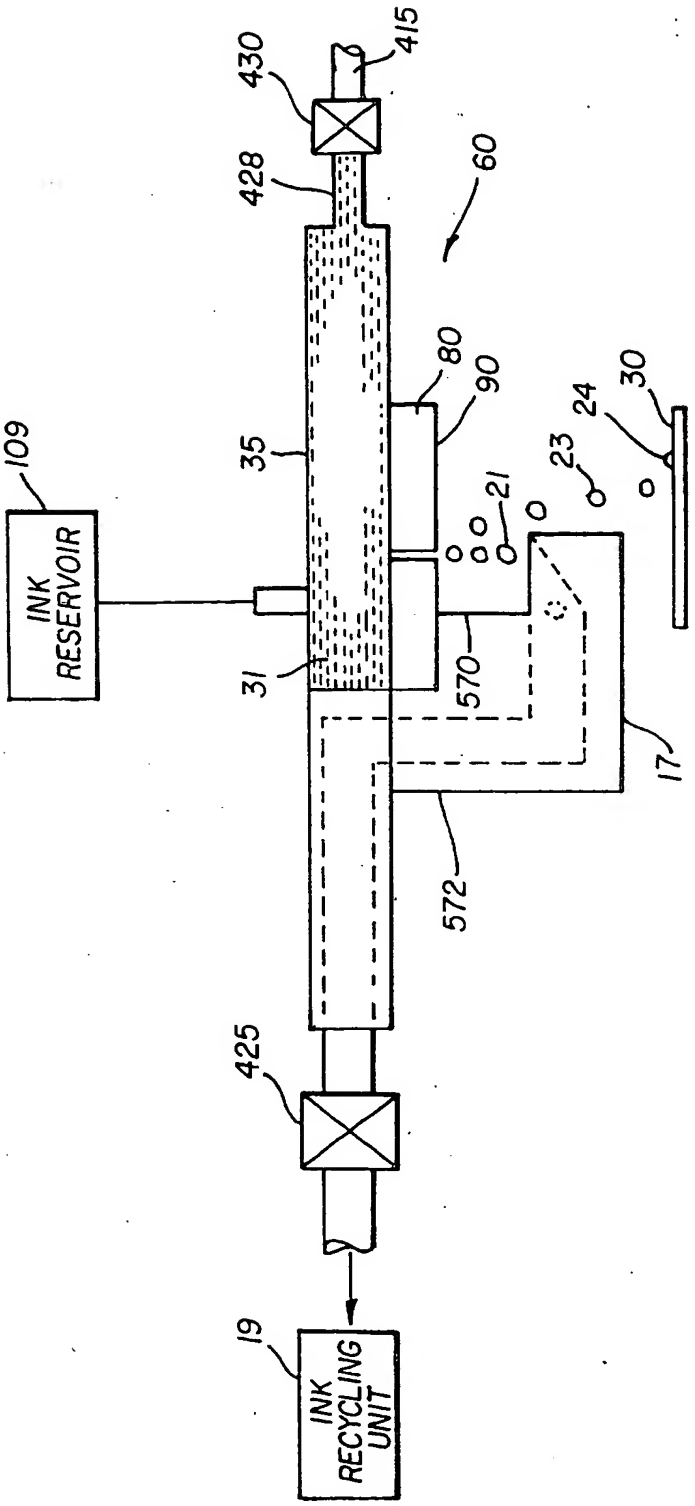
21
23
17
24
30

FIG. 2(a)


430
415
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80
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109
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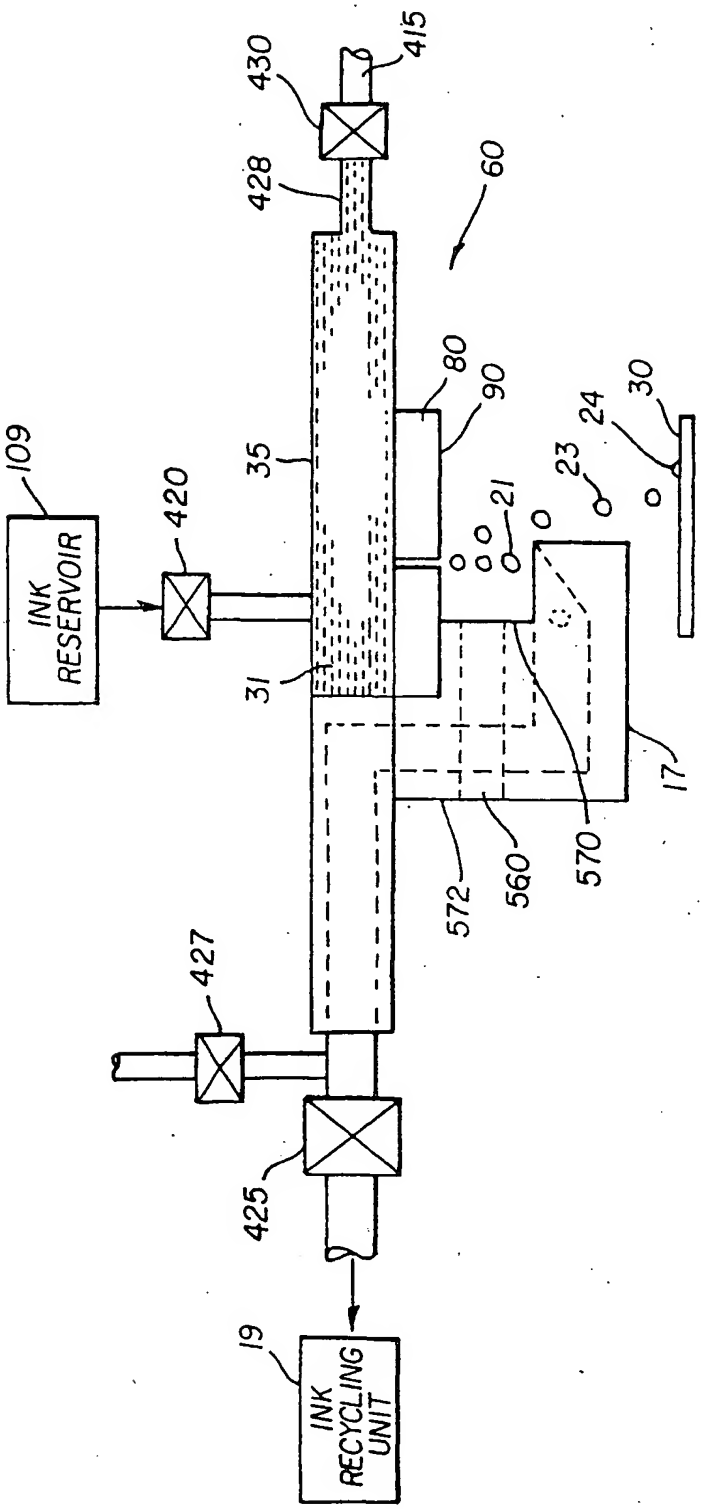
INK RECYCLING UNIT

FIG. 2(b)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30
24
23
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INK RESERVOIR
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17
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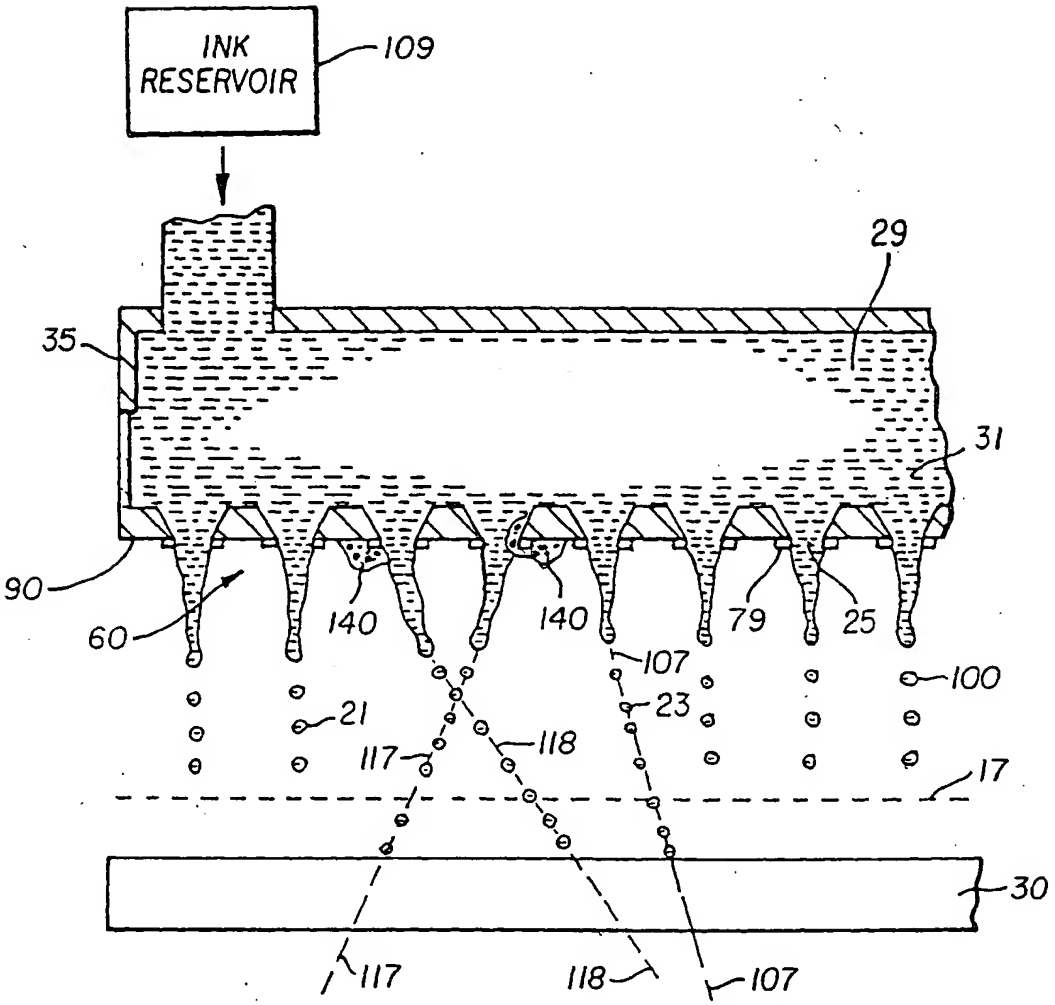
427
425
19
INK RECYCLING UNIT

FIG. 2(c)


INK RESERVOIR
109
29
35
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140
140
79
25
107
100
23
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117
17
30
117
118
107

FIG. 3

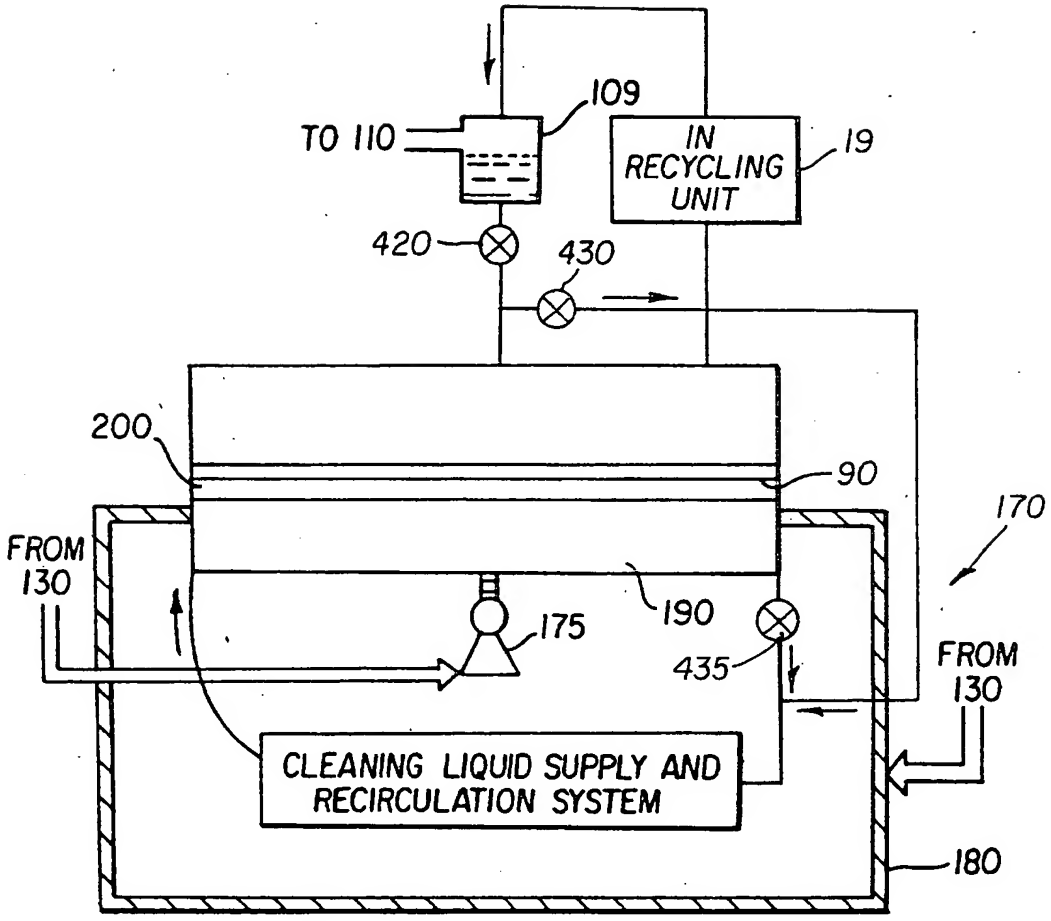
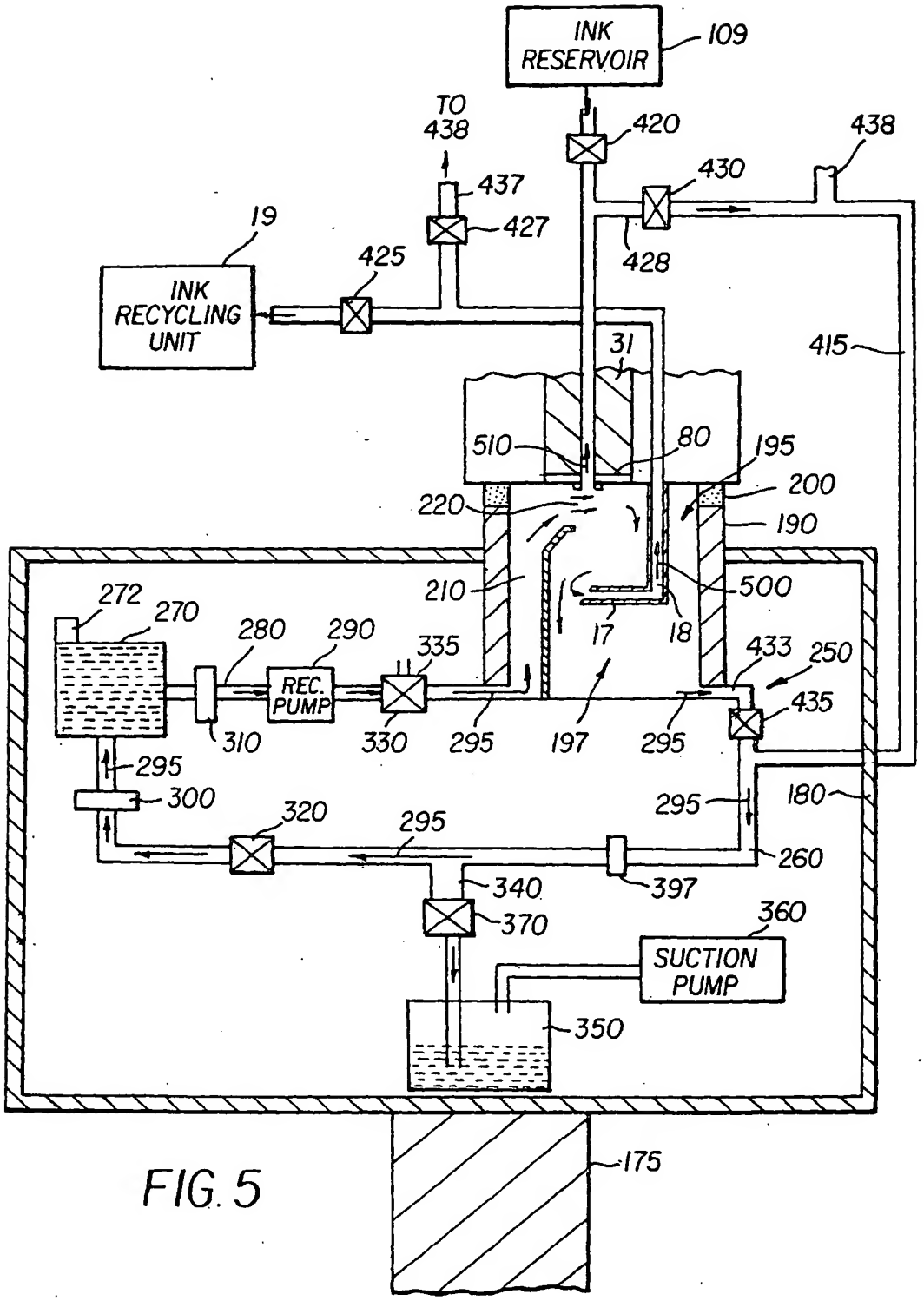

109
TO 110
IN RECYCLING UNIT
19
420
430
200
90
170
FROM 130
190
175
435
FROM 130
CLEANING LIQUID SUPPLY AND RECIRCULATION SYSTEM
180

FIG. 4


INK RESERVOIR
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TO 438
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437
430
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19
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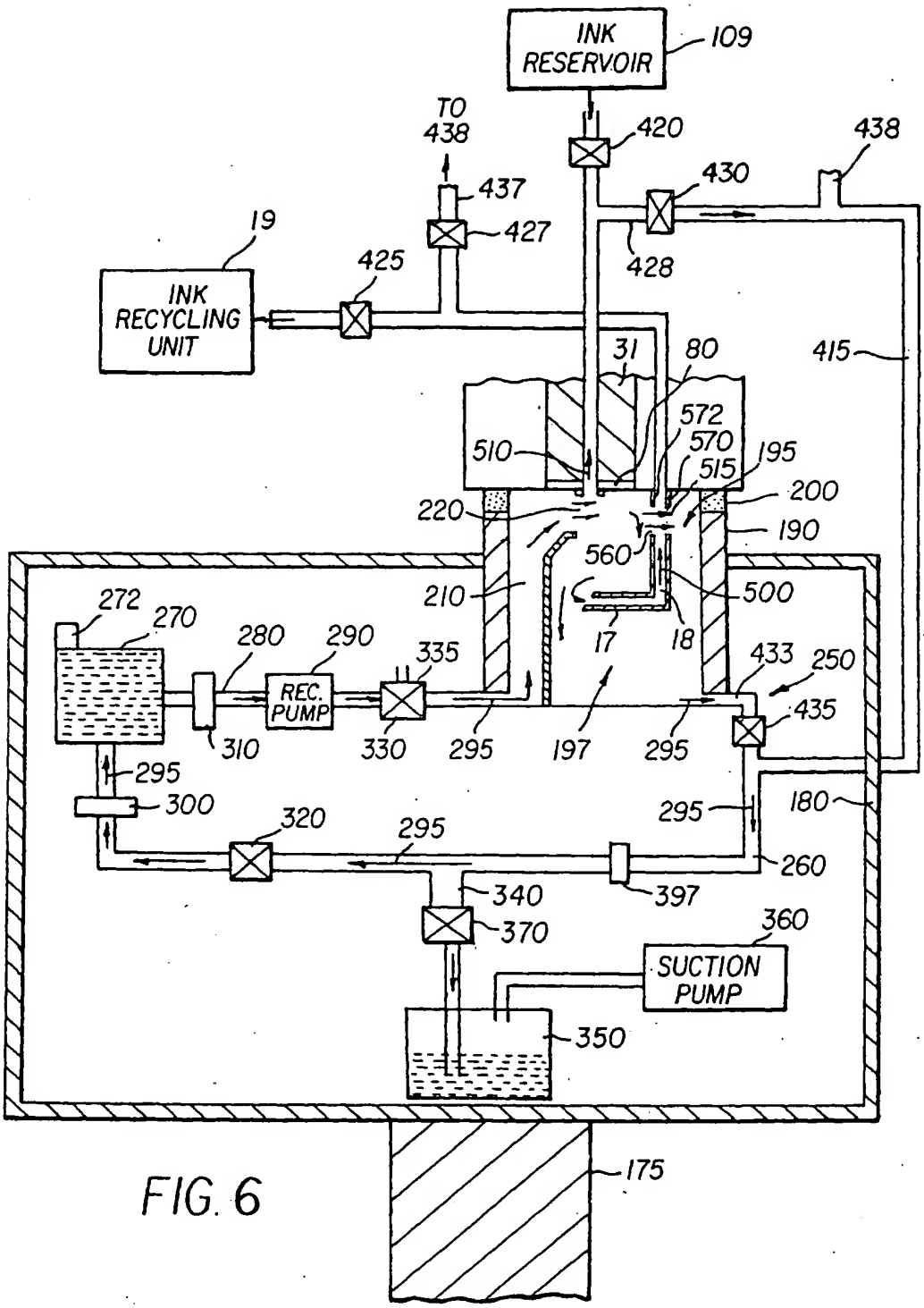
428
INK RECYCLING UNIT
31
415
510
80
195
200
220
190
210
500
272
270
280
290
335
17
18
433
250
REC. PUMP
435
310
330
295
197
295
295
300
320
295
180
295
260
340
397
370
360
SUCTION PUMP
350
175

FIG. 5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INK RECYCLING UNIT
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80
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572
570
510
195
515
200
220
190
560
210
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272
270
280
290
335
17
18
433
250
REC. PUMP
435
310
330
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197
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295
300
180
320
295
260
340
397
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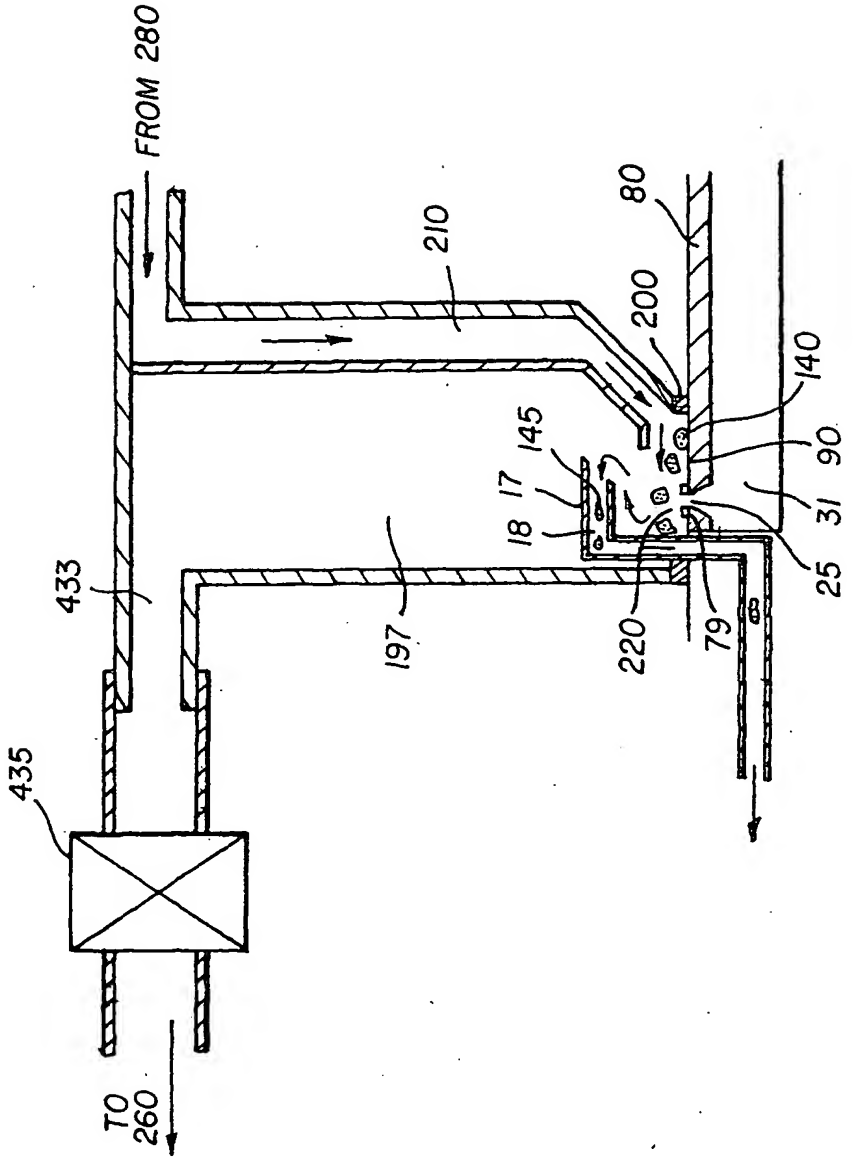
360
SUCTION PUMP
350
175

FIG. 6


FROM 280
210
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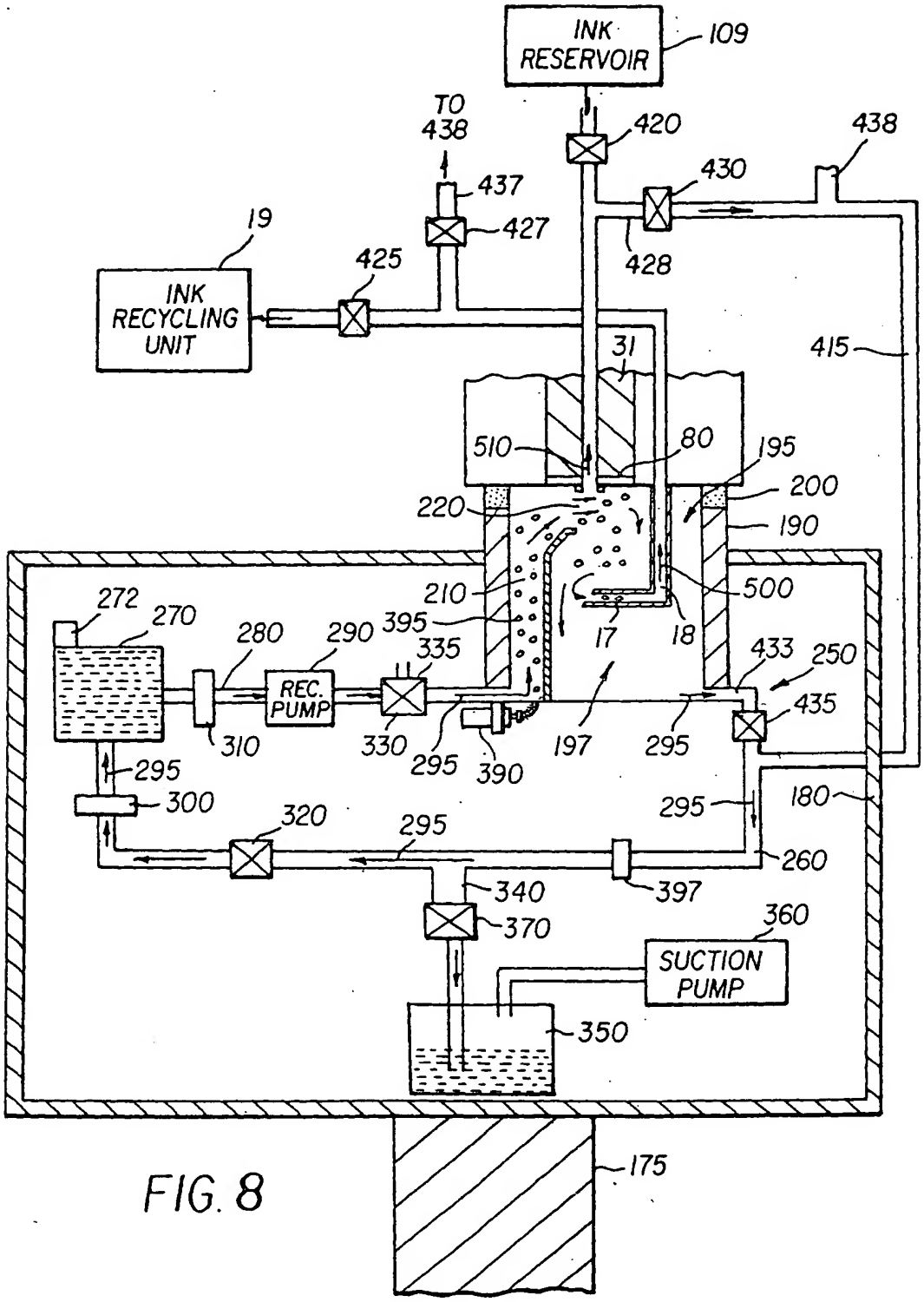
200
140
145
90
17
18
31
433
197
220
79
25
435
TO
260

FIG. 7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INK RECYCLING UNIT
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220
190
210
500
272
270
280
290
395
335
17
18
433
250
REC. PUMP
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310
330
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390
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320
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180
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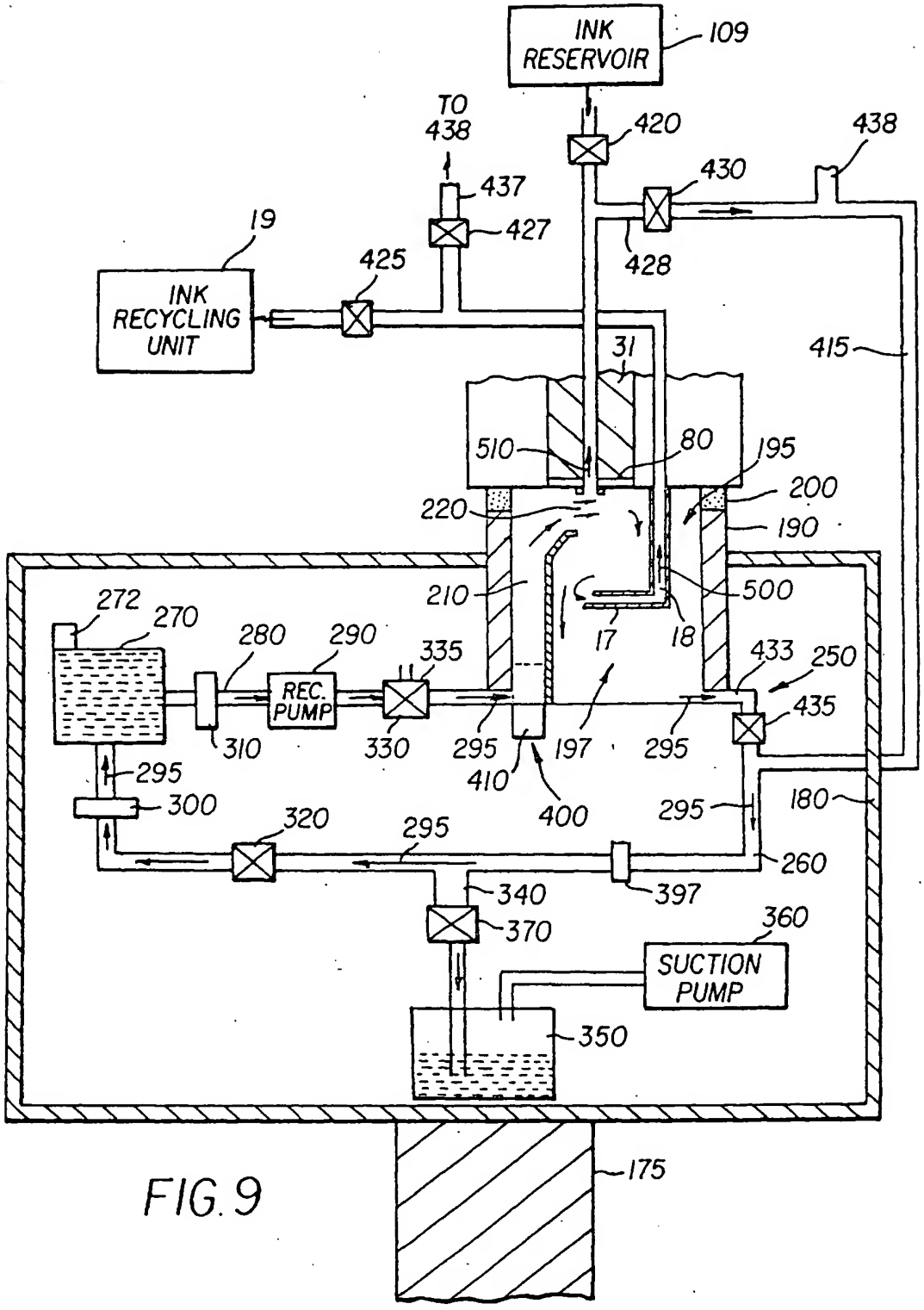
SUCTION PUMP
350
175

FIG. 8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SUCTION PUMP
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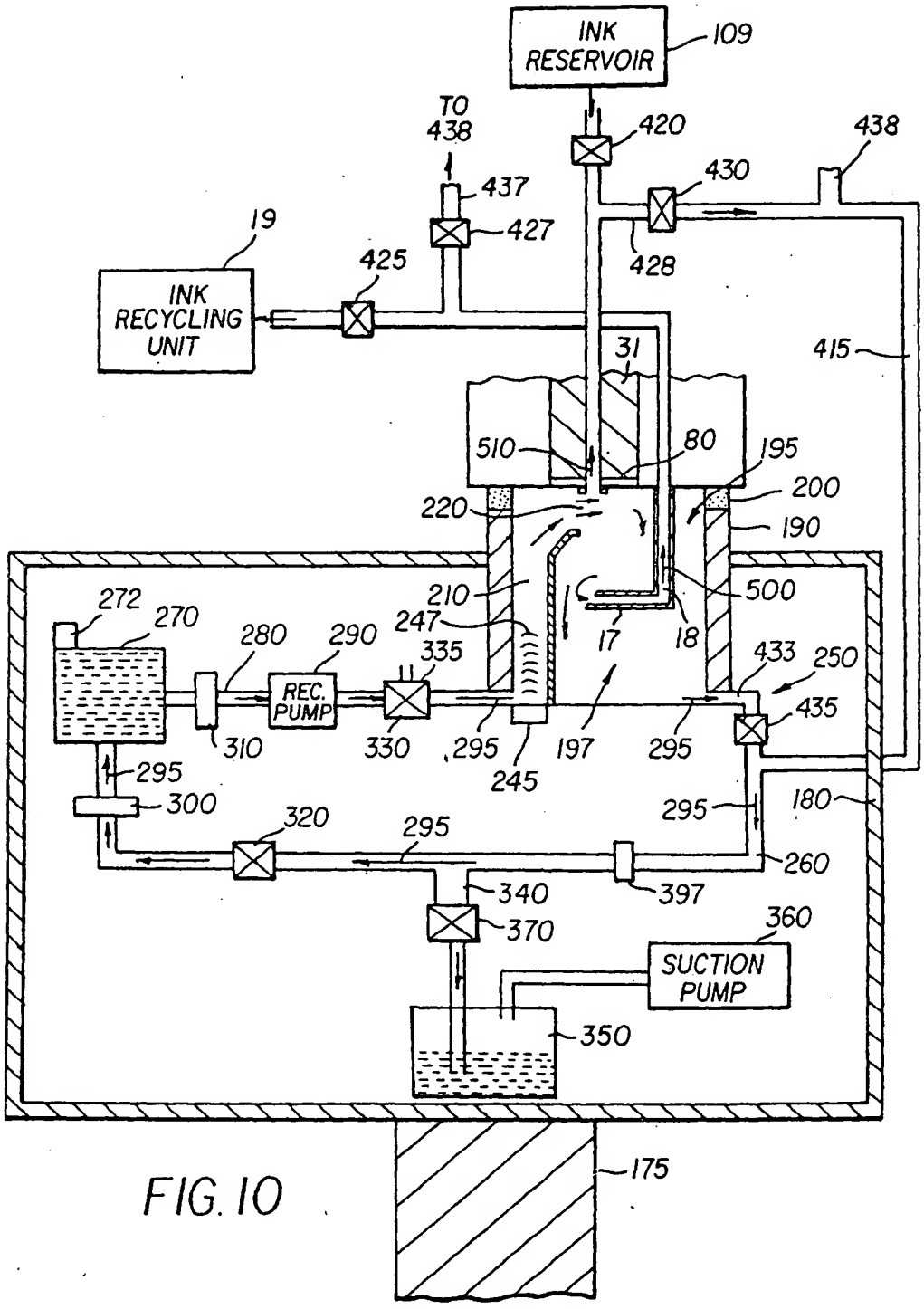
175

FIG. 9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270
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17
18
433
250
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REC. PUMP
310
330
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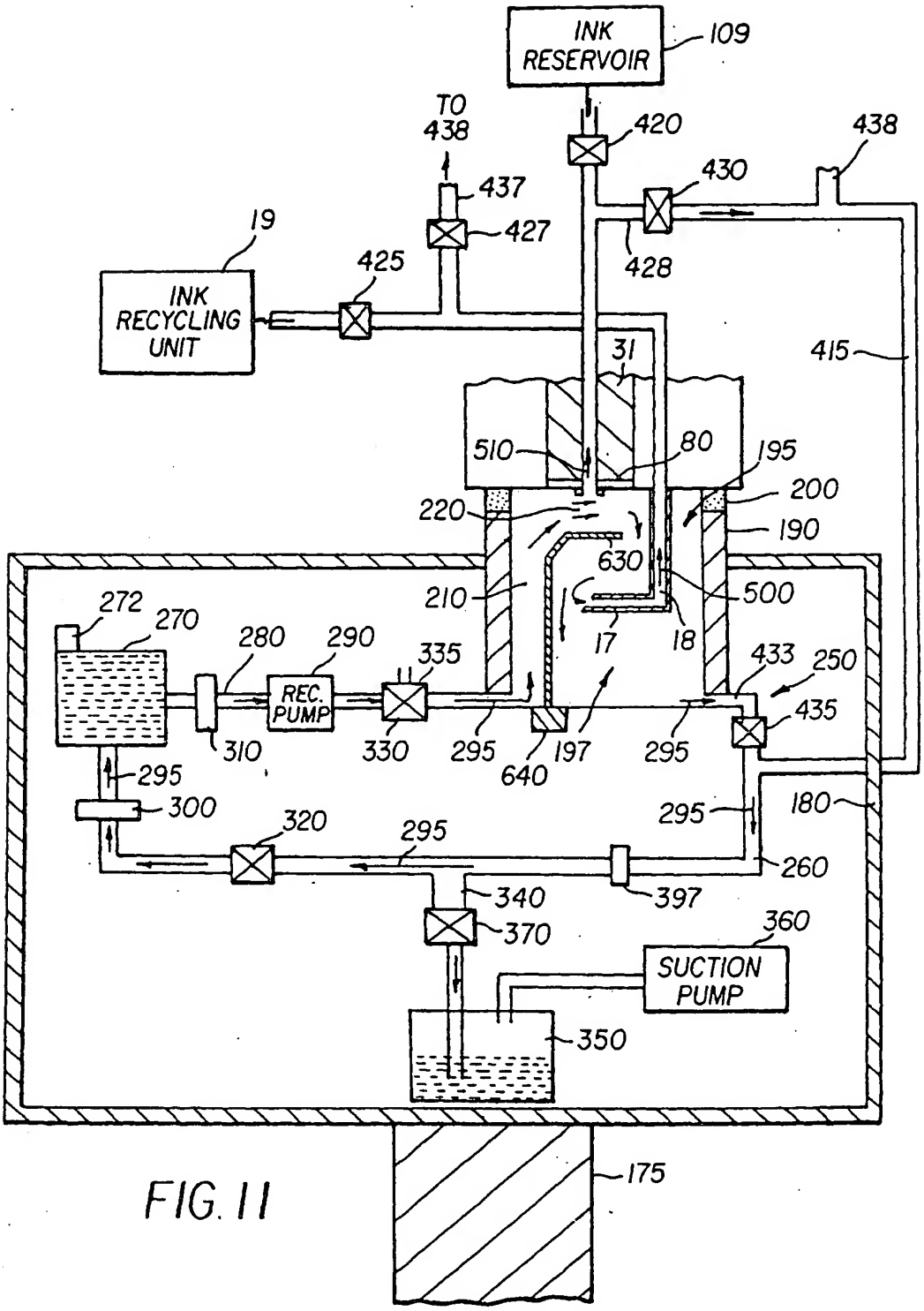
FIG. 10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18
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REC. PUMP
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FIG. 11

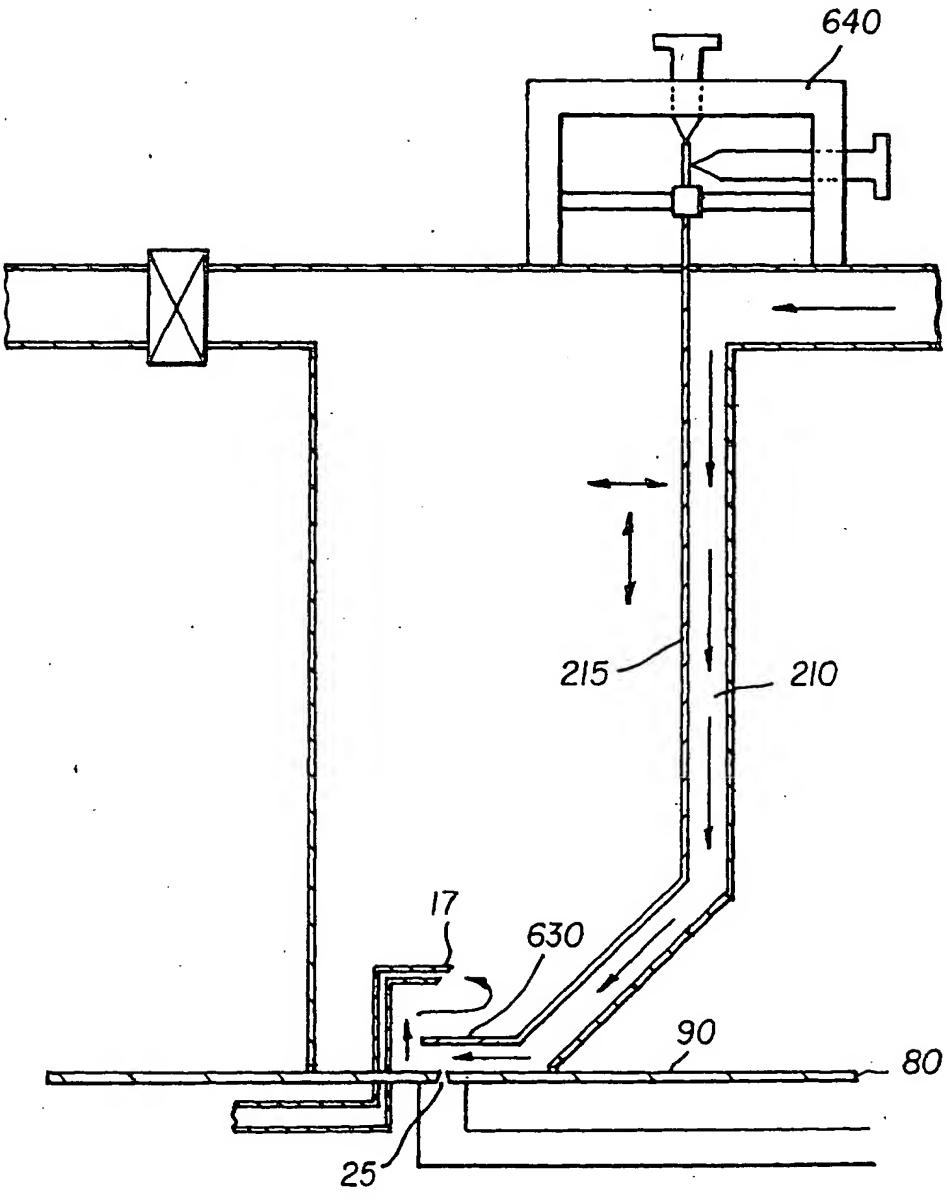

FIG. 12

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 20 2344

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 995 602 A (EASTMAN KODAK CO) 26 April 2000 (2000-04-26) * paragraph '0003! * * paragraph '0027! - paragraph '0029! *	1-10	B41J2/165 B41J2/17
A	WO 98 06583 A (GERRARD JEFFREY ;LINX PRINTING TECH (GB)) 19 February 1998 (1998-02-19) * page 14, line 26 - page 21, line 10; figure 1 *	1-10	
A	WO 86 06031 A (EASTMAN KODAK CO) 23 October 1986 (1986-10-23) * page 5, line 1 - page 15, line 5; figures *	1-10	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 October 2001	De Groot, R

CATEGORY OF CITED DOCUMENTS

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08-10-2001

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		WO 9806583 A1	19-02-1998
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		WO 8606031 A1	23-10-1986

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